REMARKS

Claims 1-12 are currently pending in this application. Claim 2 has been canceled and new claims 13-18 have been added. Claims 3 and 5 stand allowed. Claims 8 and 9 have been objected to but noted to contain allowable subject matter.

Independent claims 1, 4 and 6 have been amended herein to require that the inner core layer for retarding heat flow in the composite metal sheet be one of titanium, titanium alloy or stainless steel. These independent claims also have been amended to require that the metal layers immediately adjacent the inner heat retarding layer are pure aluminum or Alclad aluminum.

Allowed Claim 3:

Allowed independent claim 3 defines cookware comprising a multi-layer bonded composite having an inner core layer of titanium or titanium alloy, a layer of pure aluminum or Alclad aluminum bonded to opposed sides of the titanium core layer, a layer of stainless steel bonded to a first of the aluminum layers to define a cook surface, and a layer of either austenitic stainless steel or a ferromagnetic material bonded to the second of the aluminum layers to define an outer layer adjacent to the heating source.

Claim 3 defines one of the presently preferred embodiments of the present invention with an inner core layer of titanium or titanium alloy which is bonded to a layer of pure aluminum or Alclad aluminum on both sides. Due to the difference in the coefficient of heat conductivity between titanium and aluminum, the inner core layer retards heat flow in a transverse direction to cause the core layer to distribute heat in a lateral direction and, thus, minimize hot spots along the cook surface. Allowed claim 3 further includes a layer of stainless steel roll bonded to the upper layer of aluminum to define the cook surface as well as a lower layer of a non-magnetic stainless steel or a ferromagnetic material to define the outer layer. A ferromagnetic material, as pointed out in the specification, such as a carbon steel or, more preferably, a 400 series ferritic stainless steel, will make the cookware suitable for use with induction cooking ranges.

Applicant's invention resides in the discovery of employing a core layer of a material such as titanium, titanium alloy, or stainless steel roll bonded to adjacent layers of pure aluminum or Alclad aluminum on both sides which can then be used in that ordered array or further roll bonded to additional layers of materials such as

stainless steel to form a harder scratch-resistant cook surface or outer surface. The aluminum layer forming the outer surface can be hard anodized for improved appearance and scratch resistance, if desired. It is, however, the provision of a core layer having a coefficient of thermal conductivity much lower than the adjacent aluminum layers which provides the heat buffer of the present invention. Either titanium, titanium alloy, or stainless steel functions ideally as the core layer in the present invention.

None of the prior art of record teaches or suggests Applicant's claimed combination of a core layer comprising one of titanium, titanium alloy, or stainless steel bonded to adjacent layers of either pure aluminum or Alclad aluminum. All of the pending claims now require a core layer of titanium, titanium alloy, or stainless steel in a roll bonded metal composite with immediately adjacent metal layers of pure aluminum or Alclad aluminum bonded on both sides of the core layer.

Allowed Claim 5:

Allowed independent claim 5 is directed to an iron having a sole plate made from a multi-layered composite sheet or plate made from a multi-layered composite sheet or plate having improved uniform thermal transfer properties, the composite sheet comprises a plurality of roll bonded metal layers including an inner core of a metal having a coefficient of thermal conductivity lower than adjacent metal layers whereby the inner core layer retards heat flow in a transverse direction to cause the inner layer to distribute heat in a lateral direction.

Potentially Allowable Claims 8 and 9:

Claims 8 and 9 are objected to but would be allowable if rewritten in independent form. Claim 8 is directed to a method of making a multi-layered composite metal sheet which particularly sets forth that the metal of lower thermal conductivity is titanium or titanium alloy. Claim 9 calls for a layer of titanium alloy in an ordered array of pure aluminum or Alclad aluminum, with stainless steel defining the cook surface and the outer surface of the multi-layered composite sheet. Claims 8 and 9 have been amended to include stainless steel as an alternate metal with titanium or titanium alloy as forming the core layer of the composite.

All of the claims are believed to be allowable as amended, and the Examiner's reconsideration is respectfully requested in light of the following comments.

Stein et al.

Claims 1, 2, 4, 6, 7, 10 and 11 stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 3,340,597 to Stein et al. ("Stein"). Stein is broadly directed to a process for making bonded composites of aluminum or aluminum-base alloys and stainless steel by means of cold or hot rolling for use as cooking utensils, automotive trim, food processing equipment, storage tanks and highway tankers and trailers. Stein teaches that the aluminum or aluminum-base alloy may be clad on one or both sides with stainless steel or that the aluminum may form the center of a sandwich between two layers of stainless steel, if desired.

Example 3 of Stein, appearing in columns 4-5, specifically teaches a composite useful for cookware comprising a sandwich of aluminum-base alloy bonded between two stainless steel pieces. Hence, the aluminum-base alloy forms the core of the composite. The aluminum was annealed alloy 1100 and the stainless steel was a 304 type.

Example 4 of Stein, appearing in column 5 thereof, teaches a composite of stainless steel sandwiched between two aluminum alloy sheets. Both aluminum alloy sheets were heated to 900° in a furnace for 15 minutes and rolled in a two-high rolling mill. The aluminum was alloy 3004. The stainless steel was rolled at room temperature with the preheated aluminum. There is no teaching or suggestion in Stein that the composite of Example 4 would be useful for cookware or that the stainless steel core of Example 4 would act as a heat barrier or diffuser, as in the present invention.

Stein specifically teaches only two specific examples of composites for cookware. The first teaching appears in column 2, lines 37-41: "In connection with cooking utensils, such as pans, it permits employing the stainless steel on the cooking side of the vessel while simultaneously allowing utilization of the heat transmission qualities of the aluminum on the heating or fore side of the pan." Example 3 of Stein, appearing in columns 4-5, specifically relates to a composite of aluminum alloy forming the core layer sandwiched between two outer layers of stainless steel. Column 5, line 2, specifically states that the 12" by 12" blank was drawn into the form of a cooking pan.

A careful reading indicates Example 4 of Stein is directed to an application which is not for cookware, and probably is directed to a decorative strip for automotive trim. This conclusion is based upon the fact that the starting strip size is 4" by 8", i.e., nonsymmetrical and elongated, which would not lead one skilled in the art to surmise that this would be for cookware purposes. In addition, Example 4 teaches that the aluminum alloy was reduced 39% after rolling and the stainless steel was reduced 21% after rolling to form the bond between the metals. The stainless steel having been reduced by 21% could not then be drawn into a form of a pan because it would exceed its ability to be deformed further by drawing after being reduced by 21% during rolling. In other words, the stainless steel would fracture in any subsequent drawing operation to form a cookware shape.

It is well-known in the art that the maximum reduction limit for stainless steel during roll bonding is about 15% so as not to work harden the stainless steel during roll bonding to a point where subsequent drawing of pans is not possible. This fact is apparently recognized by Stein because in Example 3, for the manufacture of drawn cookware, Stain has only reduced the stainless steel 6% (see column 4, line 75) and, very importantly, for the cookware product, Stein specifically teaches that the high conductivity aluminum forms the core of the composite, with stainless steel forming the cook surface and outer surface of the cookware composite. Example 4 of Stein is for some decorative strip application and not cookware because of the very high reduction of 21% of the stainless steel during roll bonding with the aluminum alloy.

With respect to process claims 10 and 11, the Examiner states that Stein teaches a heating step including the ranges between 900-975°F, referring to column 3, lines 34-46. It will be noted that this temperature range taught by Stein is an alleged bond strengthening step which occurs "following the preliminary bonding step...", see column 3, line 34, i.e., the heating occurs after rolling. Applicants claim step (b) comprises a heating step wherein the entire ordered array of metal layers are heated in a furnace prior to the roll bonding step and requires a temperature of 550-600°F, claim 10. Stein specifically teaches, in column 3, line 1-14, that a temperature differential of at least 450°F is maintained between the stainless steel and aluminum layers for roll bonding purposes, and Stein specifically teaches at lines 11-14: "In accordance with preferred procedure, the aluminum or aluminum base alloy is heated to about 1000°F

and rolled against the stainless steel sheet at room temperature." Clearly, Stein does not teach or suggest Applicant's roll bonding heating step (b) wherein all of the metal sheets are heated to 550-600°F prior to rolling.

The Examiner concludes by stating, with respect to the distribution of heat in a lateral direction, the ability to laterally distribute heat would be "inherent to the materials and construction of the composite sheet" of Stein. Since the materials and construction are the same as those claimed by Applicant, the distribution of heat would be expected to be the same. The Examiner states that the discovery of a new property or use of a previously known composition, even if unobvious from the prior art, cannot impart patentability to claims to a known composition. Applicant is not claiming a composition *per se* but, rather, an ordered array of roll bonded sheets in cookware. Stein simply does not teach an ordered array suitable for cookware wherein a core layer of stainless steel or titanium or titanium alloy is roll bonded to layers of aluminum on upper and lower surfaces. With respect to cookware, as stated above, Stein only teaches a two-layer composite of aluminum and stainless steel where stainless steel forms the cook surface, i.e., column 2, lines 34-41, or a three-layer composite of an aluminum core with upper and lower surfaces of stainless steel in Example 3. As pointed out above, the material made in Example 4 of Stein wherein the stainless steel forms the core of a composite with outer layers of aluminum alloy is not intended for cookware. Based on the shape of the starting materials, i.e., strip form, and the very high rolling reductions, i.e., 39% and 21% reductions, one skilled in the art would instantly realize that this composite would not be suitable for a drawn cookware pan, as in Example 3 but, rather, for decorative strip. Stein also refers to the product produced in Example 4 as "strip". See, for example, column 5, lines 20 and 22. Applicant's invention as claimed in claim 1, for example, is directed to an article of manufacture, i.e., drawn cookware, and is not a composition of matter. The decorative strip produced by Stein in Example 4 is not cookware and, thus, cannot anticipate Applicant's claims, nor does it suggest the manufacture of cookware having an inner core of a low thermal conductivity material such as titanium or stainless steel. Stein's only teaching with respect to cookware specifically teaches the use of aluminum for its high heat transmission qualities. There is nothing in Stein regarding the use of stainless steel as a heat buffer in a core layer of a composite for making cookware, as in the present

invention. The Examiner's reconsideration and removal of Stein as a reference is respectfully requested.

Racz

Claims 1 and 4 stand rejected under 35 U.S.C. §102(b) as being anticipated by United States Patent No. 3,788,513 to Racz. Racz specifically teaches a multiple ply laminated cookware construction comprising a core ply of carbon steel, represented by numeral 14 in Fig. 2, coated on one or both sides with a thin layer or ply of a non-ferrous metal such as aluminum, plies 16 and 18. The aluminum may be applied by one of a number of coating processes such as by spraying, dipping, cladding and the like, to form plies 16 and 18, with the base core 14 of mild or carbon steel (see column 5, lines 25-35). The exterior ply 18 may also be stainless steel instead of aluminum. Racz also teaches that the thickness of the carbon steel core ply 14 may be increased along the upstanding sidewall 11 of the container compared to the bottom wall 10, as shown in Fig. 2, so that "heat transfer through the bottom of the container to the food is unimpeded" and to reduce heat transfer from the food through the vertical sidewall 11 of the container because of the greater thickness of the carbon steel in that region (see column 6, lines 25-42).

It will be noted that Applicant specifically claims one of titanium, titanium alloy or stainless steel as the material of the core layer of the present invention. It must also be observed that stainless steel has a significantly lower coefficient of thermal conductivity than does the carbon steel of Racz. Applicant has enclosed herewith for the Examiner's convenience a series of engineering tables which compare the thermal conductivity of various metals including aluminum, stainless steel and carbon steel. It will be seen that stainless steel, such as a typical 18% Cr/8% Ni stainless steel, has a thermal conductivity of 16.3 w/m°K and titanium has a comparable thermal conductivity coefficient of 15.6 w/m°K compared with a coefficient of thermal conductivity for 0.5 carbon steel of 54.0 w/m°K. It will be appreciated, therefore, that the coefficient of thermal conductivity of a mild carbon steel, such as taught by Racz, is several times greater than the coefficient of thermal conductivity of stainless steel as the stainless steel or titanium claimed by Applicant. Another shortcoming of mild steel is its propensity to rust, as recognized by Racz at column 2, lines 10-18. Mild steel must be

protected by enamel coating or other coating and the exposed edges must be protected through the use of a corrosion-resistant, decorative channeled rim 26 shown in Fig. 2. Otherwise, the carbon steel would easily rust when exposed to water. In addition, the pot of Racz is naturally quite heavy compared to a cookware construction according to the present invention. A core layer of stainless steel in the present invention can be relatively thin due to its much lower coefficient of thermal conductivity than the mild steel of Racz. The titanium core layer of the present invention is even better with respect to weight because of the very low relative density of titanium vs. carbon steel. The non-corrosive properties of stainless steel and titanium, likewise, provide corrosion resistance at any exposed edges and avoid the problems of the Racz construction.

The use of carbon steel in Racz is intended to insulate the sidewalls of the pot so as to contain heat therein and to increase the strength of the pot while at the same time reduce the cost of construction.

Racz specifically teaches, at column 6, lines 40-47:

> "Moreover, by increasing the thickness of the core ply 14 in the sidewall 11, the strength of the sidewall of the container, which is exposed to the maximum lateral stresses, is further increased. In addition to the added insulative qualities realized by the increase in thickness of the steel core ply 14 and the decrease in thickness of the aluminum plies 16 and 18 in the sidewall, further insulation on the sidewalls is realized by way of the decorative ceramic coating 20, which itself acts as an insulator."

Clearly, Racz does not contemplate roll bonding a composite of stainless steel between layers of pure aluminum or Alclad aluminum, as required in the present claims. Racz also specifically teaches that the function of the mild carbon steel base ply 14 is to reduce cost and provide strength to the construction, for example, Racz teaches in column 5, lines 56-64:

> "However, in the laminated container of my invention, the aluminum plies 16 and 18 act primarily as bonding, heat conducting, and rust preventing layers and the container strength is provided by the <u>relatively inexpensive steel base core ply 14</u>, the strength of which is substantially unchanged at the above-mentioned temperatures" (application or porcelain coatings).

> "Thus, in the laminated container of my invention softening of the aluminum plies 16 and 18 is not an important consideration."

Hence, Racz is teaching the use of a relatively inexpensive mild carbon steel base ply 14 as an economical way to construct a cooking pot and certainly does not suggest Applicant's core layer of titanium, titanium alloy or stainless steel.

Racz teaches that the carbon steel should be protected against rusting and that a decorative porcelain coating 20 may be applied for that purpose, see col. 2, lines 10-15 and col. 5, lines 25-44. The porcelain coating is fired at 1050°F (col. 5, lines 40-43). Further, it is also known that aluminum is soluble in carbon steel at elevated temperatures, and if the cookware should be heated to temperatures above about 620°F, a brittle intermetallic phase is formed between the aluminum and carbon steel which can occur during use or during manufacture. The formation of the brittle intermetallic phase may cause <u>delamination between the aluminum and carbon steel layers</u> and, at the very least, a heat insulation layer or gap to develop. On the other hand, the aluminum/stainless steel interface of the present invention requires a solution temperature of greater than 1,080°F in order to form any brittle intermetallic phase. This is because of the presence of chromium in the stainless steel alloy. The 1,080°F solution temperature would not be reached during cooking and, hence, no delamination or brittle intermetallic forms in the aluminum-stainless steel construction of Applicant's invention. Titanium and titanium alloy also have a very high solution temperature when bonded to aluminum and also would avoid the problem of the brittle metallic formation in the Racz carbon steel/aluminum construction.

Because of the difference in the claimed construction and that of Racz, the Examiner's reconsideration is respectfully requested.

Claims 1, 2 and 4 also stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 3,966,426 to McCoy et al., U.S. Patent No. 4,646,935 to Ulam, U.S. Patent No. 5,952,112 to Spring, or U.S. Patent No. 5,532,460 to Okato.

<u>McCoy</u>

The Examiner states that McCoy, in Fig. 3, allegedly discloses a multilayered composite sheet made from a plurality of layers including an inner layer of a lower coefficient of thermal conductivity material such as 304 type stainless steel

between layers of higher coefficient of thermal conductivity materials such as aluminum. Contrary to what the Examiner states, McCoy in Fig. 3 actually discloses an inner layer of 304 stainless steel sandwiched between a layer of aluminum and a layer of 1008 carbon steel. Applicant's claims, as amended, now require that the core layer of titanium, titanium alloy or stainless steel be immediately adjacent, i.e., contacting the layers of pure aluminum or Alclad aluminum and bonded on both sides thereof by said aluminum layers.

Fig. 3 of McCoy only shows one layer of aluminum 18 bonded to layer 22 of 304 stainless steel which, in turn, is bonded to a layer 16 of carbon steel and itself bonded to a layer 20 of 304 stainless steel. McCoy does not teach or suggest a core layer of titanium or stainless steel forming a core layer bonded to upper and lower layers of pure aluminum or Alclad aluminum, as presently claimed. Hence, McCoy does not anticipate nor render obvious the present invention.

Ulam

The Examiner states that Ulam, in Fig. 3, discloses a multilayered composite sheet made from a plurality of layers including an inner layer of a lower coefficient of thermal conductivity material, such as stainless steel, sandwiched between layers of a higher coefficient of thermal conductivity material such as aluminum. Referring to Fig. 3 of Ulam, the composite metal cookware contains, starting from the cooking surface to the heat source surface, the following roll bonded layers: stainless steel layer 40, pure aluminum layer 38, aluminum alloy layer 34, pure aluminum layer 37, copper core 30, pure aluminum layer 36, aluminum alloy layer 33, pure aluminum layer 35, austenitic stainless steel layer 22, carbon steel layer 20, and outer austenitic stainless steel layer 21. Once again, there is no inner core layer of a lower thermal conductivity material such as stainless steel or titanium directly bonded to layers of higher thermal conductivity materials such as aluminum. It will be noted that the core layer 30 of Ulam in Fig. 3 is actually a high conductivity material, copper. The carbon steel layer 20 is bonded to adjacent layers of austenitic stainless steel which, likewise, do not have high thermal conductivity. Ulam simply does not teach or suggest the presently claimed construction.

Spring

The Examiner states that Spring, in Fig. 6, discloses a multilayered composite sheet made from a plurality of layers including an inner layer of a lower coefficient of thermal conductivity material such as stainless steel between layers of higher coefficient of thermal conductivity materials such as aluminum for making cookware. With reference to Fig. 6 of Spring, there is actually disclosed a multilayered composite containing, from the inner cooking surface to the outer surface, a composite structure as follows: an inner cook surface layer 3 of austenitic stainless steel, bonded to a carbon steel layer 4, bonded to an austenitic stainless steel layer 3, bonded to an aluminum alloy layer 5, bonded to a pure aluminum layer 1, bonded to an aluminum alloy layer 5, bonded to an austenitic stainless steel layer 3, bonded to a carbon steel layer 4, bonded to an outer austenitic stainless steel layer 3. Hence, Spring does not disclose a layer of lower conductivity material such as stainless steel bonded directly to and between layers of aluminum. In Spring, all of the lower conductivity materials such as carbon steel are sandwiched between layers of lower conductivity austenitic stainless steel at the outer and inner surfaces of the composite. In Spring, the higher conductivity layers of aluminum are in the core of the structure. Clearly, Spring does not teach or suggest the presently claimed invention.

Okato

The Examiner states, with reference to Okato, Table 1, examples 8 and 9, there is allegedly disclosed a multilayered composite sheet made from a plurality of layers including an inner layer of a lower coefficient of thermal conductivity material such as TiAlSnZrMoSi between layers of higher coefficient of thermal conductivity materials such as TiAlV. This does not appear to be a correct statement since Okato actually states that the inner layer of TiAlSnZrMoSi has a lower "specific resistance value" than the adjacent layers. This refers to a resistivity value concerning electromagnetic induction cooking and not to thermal conductivity. Hence, Okato does not teach or suggest the present invention. Further, there is no mention of a core layer of titanium, titanium alloy or stainless steel roll bonded to immediate layers of pure aluminum or Alclad aluminum, as now required in the present claims.

In summary, none of the prior art, when taken alone or in combination, teaches or suggests cookware made from a composite metal structure having an inner core layer of titanium, titanium alloy or stainless steel roll bonded to adjacent layers of pure aluminum or Alclad aluminum. Probably the closest prior art is that of Racz, but the construction of Racz would be inferior to Applicant's invention due to the considerably higher coefficient of thermal conductivity of carbon steel vs. stainless steel, as discussed above. In addition, Racz fails to appreciate the solubility of aluminum in carbon steel at temperatures approaching 620°F and the formation of the brittle intermetallic phase which forms between aluminum and carbon steel. This serious delamination problem is completely avoided in Applicant's construction which utilizes a core layer of roll bonded titanium, titanium alloy or stainless steel and immediately adjacent layers of pure aluminum or Alclad aluminum.

In light of the above discussion, the Examiner's reconsideration and favorable action are respectfully requested. If any matters remain outstanding, the Examiner is invited to telephone Applicant's undersigned attorney to discuss the application and claims in greater detail in order to advance the application toward an early allowance.

Respectfully submitted,

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Engineering Reference
Physical Properties of Aluminum Alloys

Alloy	Avg. Coefficient of Thermal Expansion 20° - 100°C	Avg. Coefficient of Thermal Expansion 68° - 212°F	Melting Range Approx.	Temper	Thermal Conductivity at 77°F/25°C	Thermal Conductivity at 77°F/25°C	Electrical Conductivity % of Cu 68°F/20°	Electrical Conductivity % of Cu 68°F/20°
	μm/m-°C	μin/in-°F	°F		W/m-K	BTU-in/ hr-ft²- F	Equal volume	Equa weig
1060	23.58	13.1	1190-1215	O	234	1625	62	204
				H18	231	1600	61	201
1100	~~23.58~~	~~13.1~~	~~1190-1215~~	~~O~~	~~222~~	~~1540~~	~~59~~	~~194~~
				H18	218	1510	57	187
1350	23.76	13.2	1195-1215	All	234	1625	62	204
2011	22.86	12.7	1005-1190	T3	151	1050	39	123
				T8	171	1190	45	142
2014	23.04	12.8	945-4480	O	193	1340	50	159
				T4	134	930	34	108
				T6	154	1070	40	127
2017	23.58	13.1	955-1185	O	193	1340	50	159
				T4	134	930	34	108
2018	22.32	12.4	945-1180	T61	154	1070	40	127
2024	23.22	12.9	935-1180	O	193	1340	50	159
				T3,T4,T361	121	840	30	96
				T6,T81,T861	151	1050	38	122
2025	22.68	12.6	970-1185	T6	154	1070	40	127
2036	23.4	13	1030-1200	T4	159	1100	41	135
2117	23.76	13.2	1030-1200	T4	154	1070	40	130
2124	22.86	12.7	935-1180	T851	152	1055	38	122
2218	22.32	12.4	940-1175	T72	154	1070	40	126
2219	22.32	12.4	1010-1190	O	171	1190	44	138
				T31,T37	112	780	28	88
				T6,T81,T87	121	840	30	94
2618	22.32	12.4	1020-1180	T6	147	1020	37	120
3003	23.2	12.9	1190-1210	O	193	1340	50	163
				H12	163	1130	42	137
				H14	159	1100	41	134
				H18	154	1070	40	130
~~3004~~	~~23.94~~	~~13.3~~	~~1165-1210~~	~~All~~	~~163~~	~~1130~~	~~42~~	~~137~~
3105	23.58	13.1	1175-1210	All	171	1190	45	148
4032	19.44	10.8	990-1060	O	154	1070	40	132
				T6	138	960	35	116
4043	22.14	12.3	1065-1170	O	163	1130	42	140
4045	21.06	11.7	1065-1110	All	171	1190	45	151
4343	21.6	12	1070-1135	All	180	1250	45	158
5005	23.76	13.2	1170-1210	All	200	1390	52	172
5050	23.76	13.2	1155-1205	All	193	1340	50	165
5052	23.76	13.2	1125-1200	All	138	960	35	116

5056	24.12	13.4	1055-1180	O	117	810	29	98
				H38	108	750	27	91
5083	23.76	13.2	1095-1180	O	117	810	29	98
5086	23.76	13.2	1085-1185	All	125	870	31	104
5154	23.94	13.3	1100-1190	All	125	870	32	107
5252	23.76	13.2	1125-1200	All	138	960	35	116
5254	23.94	13.3	1100-1190	All	125	870	32	107
5356	24.12	13.4	1060-1175	O	117	810	29	98
5356	24.12	13.4	1060-1175	O	117	810	29	98
5454	23.58	13.1	1115-1195	O	134	930	34	113
				H38	134	930	34	113
5456	23.94	13.3	1055-1180	O	117	810	29	98
5457	23.76	13.2	1165-1210	All	176	1220	46	153
5652	23.76	13.2	1125-1200	All	138	960	35	116
5657	23.76	13.2	1180-1215	All	205	1420	54	180
6005	23.4	13.0	1125-1210	T1	180	1250	47	155
				T5	189	1310	49	161
6053	23.04	12.8	1070-1205	O	171	1190	45	148
				T4	154	1070	40	132
				T6	163	1130	42	139
6061	23.58	13.1	1080-1205	O	180	1250	47	155
				T4	154	1070	40	132
				T6	167	1160	43	142
6063	23.4	13.0	1140-1210	O	218	1510	58	191
				T1	193	1340	50	181
				T5	209	1450	55	181
				T6,T83	200	1390	53	175
6066	23.22	12.9	1150-1210	T6	218	1510	57	188
				T61	222	1540	59	194
				T63	218	1510	58	191
				T64	226	1570	60	198
				T65	218	1510	58	191
6105	23.4	13	1110-1200	T1	176	1220	46	151
				T5	193	1340	50	165
6151	23.22	12.9	1090-1200	O	205	1420	54	178
				T4	163	1130	42	138
				T6	171	1190	45	148
6201	23.4	13	1125-1210	T81	205	1420	54	180
6253			1100-1205					
6262	23.4	13	1080-1205	T9	171	1190	44	145
6351	23.4	13	1030-1200	T6	176	1220	46	151
6463	23.4	13	1140-1210	T1	193	1340	50	135
				T5	209	1450	55	181
				T6	244	1690	53	175
6951	23.4	13	1140-1210	O	213	1480	56	186
				T6	197	1370	52	172
7049	23.4	13	890-1175	T73	154	1070	40	132
7050	23.04	12.8	910-1165	T74	157	1090	41	135
7072	23.58	13.1	1185-1215	O	222	1540	59	193
7075	23.58	13.1	890-1175	T6	130	900	33	105
7175	23.4	13.0	890-1175	T74	156	1080	39	124
7178	23.4	13.0	890-1175	T6	125	870	31	98
7475	23.22	12.9	890-1175	T61,T651	138	960	35	116
				T76,T761	147	1020	40	132
				T7351	163	1130	42	139
8017	23.58	13.1	1190-1215	H12,H22			59	193
				H212			61	200
8030	23.58	13.1	1190-1215	H221	231	1600	61	201

8176	23.58	13.1	1190-1215	H24	231	1600	61	201

Phone: 972-312-8609 FAX:

Thermal Properties w/m °K

[illegible]	[illegible]	[illegible]	[illegible]
Aluminum, 2024, Temper-T3	121.0	2.8E+3	795.0
Aluminum, 2024, Temper-T351	143.0	2.8E+3	795.0
Aluminum, 2024, Temper-T4	121.0	2.8E+3	795.0
Aluminum, 5052, Temper-H32	138.0	2.68E+3	963.0
Aluminum, 5052, Temper-O	144.0	2.69E+3	963.0
Aluminum, 6061, Temper-O	180.0	2.71E+3	1.256E+3
Aluminum, 6061, Temper-T4	154.0	2.71E+3	1.256E+3
Aluminum, 6061, Temper-T6	167.0	2.71E+3	1.256E+3
Aluminum, 7075, Temper-O	130.0	2.8E+3	1.047E+3
Aluminum, 7075, Temper-T6	130.0	2.8E+3	1.047E+3
Aluminum, A356, Temper-T6	128.0	2.76E+3	900.0
Aluminum, Al-Cu, Duralumin, 95%Al-5%Cu	164.0	2.787E+3	883.0
Aluminum, Al-Mg-Si, 97%Al-1%Mg-1%Si-1%Mn	177.0	2.707E+3	892.0
Aluminum, Al-Si, Alusil, 80%Al-20%Si	161.0	2.627E+3	854.0
Aluminum, Al-Si, Silumim, 86.5%Al-1%Cu	137.0	2.659E+3	867.0
Aluminum, Pure	220.0	2.707E+3	896.0
Beryllium, Pure	175.0	1.85E+3	1.885E+3
Brass, Red, 85%Cu-15%Zn	151.0	8.8E+3	380.0
Brass, Yellow, 65%Cu-35%Zn	119.0	8.8E+3	380.0
Copper, Alloy, 11000	388.0	8.933E+3	385.0
Copper, Aluminum bronze, 95%Cu-5%Al	83.0	8.666E+3	410.0
Copper, Brass, 70%Cu-30%Zn	111.0	8.522E+3	385.0
Copper, Bronze, 75%Cu-25%Sn	26.0	8.666E+3	343.0
Copper, Constantan, 60%Cu-40%Ni	22.7	8.922E+3	410.0

w/m °K

Steel, Carbon, 1.0%C	43.0	7.801E+3	473.0
Steel, Carbon, 1.5%C	36.0	7.753E+3	486.0
Steel, Chrome, Cr0%	73.0	7.897E+3	452.0
Steel, Chrome, Cr1%	61.0	7.865E+3	460.0
Steel, Chrome, Cr20%	22.0	7.689E+3	460.0
Steel, Chrome, Cr5%	40.0	7.833E+3	460.0
Steel, Chrome-Nickel, 15%Cr-10%Ni	19.0	7.865E+3	460.0
Steel, Chrome-Nickel, 18%Cr-8%Ni	16.3	7.817E+3	460.0
Steel, Chrome-Nickel, 20%Cr-15%Ni	15.1	7.833E+3	460.0
Steel, Chrome-Nickel, 25%Cr-20%Ni	12.8	7.865E+3	460.0
Steel, Invar, 36%Ni	10.7	8.137E+3	460.0
Steel, Nickel, Ni0%	73.0	7.897E+3	452.0
Steel, Nickel, Ni20%	19.0	7.933E+3	460.0
Steel, Nickel, Ni40%	10.0	8.169E+3	460.0
Steel, Nickel, Ni80%	35.0	8.618E+3	460.0
Steel, SAE 1010	59.0	7.832E+3	434.0
Steel, SAE 1010, Sheet	63.9	7.832E+3	434.0
Steel, Stainless, 316	16.26	8.0272E+3	502.1
Steel, Tungsten, W0%	73.0	7.897E+3	452.0
Steel, Tungsten, W1%	66.0	7.913E+3	448.0
Steel, Tungsten, W10%	48.0	8.314E+3	419.0
Steel, Tungsten, W5%	54.0	8.073E+3	435.0
Tin, Cast, Hammered	62.5	7.352E+3	226.0
Tin, Pure	64.0	7.304E+3	226.5
Titanium	15.6	4.51E+3	544.0
Tungsten	180.0	19.35E+3	134.4
Zinc, Pure	112.2	7.144E+3	384.3

Copper, Drawn Wire	287.0	8.8E+3	376.0
Copper, German silver, 62%Cu-15%Ni-22%Zn	24.9	8.618E+3	394.0
Copper, Pure	386.0	8.954E+3	380.0
Copper, Red brass, 85%Cu-9%Sn-6%Zn	61.0	8.714E+3	385.0
Gold, Pure	318.0	18.9E+3	130.0
Invar, 64%Fe-35%Ni	13.8	8.13E+3	480.0
Iron, Cast	55.0	7.207E+3	456.0
Iron, Pure	71.8	7.861E+3	452.0
Iron, Wrought, 0.5%C	59.0	7.849E+3	460.0
Kovar, 54%Fe-29%Ni-17%Co	16.3	8.36E+3	432.0
Lead, Pure	35.0	11.373E+3	130.0
Magnesium, Mg-Al, Electrolytic, 8%Al-2%Zn	66.0	1.81E+3	1.0E+3
Magnesium, Pure	171.0	1.746E+3	1.013E+3
Molybdenum	130.0	10.22E+3	251.0
Nichrome, 80%Ni-20%Cr	12.0	8.4E+3	420.0
Nickel, Ni-Cr, 80%Ni-20%Cr	12.6	8.314E+3	444.0
Nickel, Ni-Cr, 90%Ni-10%Cr	17.0	8.666E+3	444.0
Nickel, Pure	99.0	8.906E+3	445.9
Silver, Pure	418.0	10.51E+3	230.0
Solder, Hard, 80%Au-20%Sn	57.0	15.0E+3	15.0
Solder, Hard, 88%Au-12%Ge	88.0	15.0E+3	No Data
Solder, Hard, 95%Au-3%Si	94.0	15.7E+3	147.0
Solder, Soft, 60%Sn-40%Pb	50.0	9.29E+3	180.0
Solder, Soft, 63%Sn-37%Pb	51.0	9.25E+3	180.0
Solder, Soft, 92.5%Pb-2.5%Ag-5%In	39.0	12.0E+3	No Data
Solder, Soft, 95%Pb-5%Sn	32.3	11.0E+3	134.0
Steel, Carbon, 0.5%C	54.0	7.833E+3	465.0